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A Study on Red Tide Detection Technique by Comparison of Spectral Similarity

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Abstract. This study proposes a method to detect red tide(*Cochlodinium polykrikoides*) using Water-leaving radiance data and Absorption Coefficients data obtained from Geostationary Ocean Color Imager(GOCI) in the South Sea of Korea. The proposed algorithm detected the red tide pixels from the satellite image through the two-step filtering process. In the first step, clear water pixels were removed using the spectral slope change of Water-leaving radiance spectrum from 490nm to 555nm. In the second step, turbid water pixels were removed using the dynamic time warping algorithm for detects red tide pixels. The calculation process that proposed algorithm in this study was shorter than the previous study. In addition, proposed algorithm could be detected red tide pixel from turbid water as well as clear water.

Keywords: Harmful algal bloom, Red Tide, Dynamic Time Warping

1 Introduction

Red tide is a phenomenon in which sea water discolors or physically damages creatures due to the blooming of phytoplankton. Korea has suffered an average of $7.2 million annually in damage in the last 20 years since the loss of about 66 million dollars in 1995. In Korea, red tide were mainly produced by diatoms until the 1980s. However, the frequency of red tide by the dinoflagellates has increased in the 1990s.

Detection of red tide in the early stage of occurrence and establish a response strategy are the most effective to mitigate the damage(Kim *et al.*, 2007). It is difficult to monitor the red tide caused by the dinoflagellate by using the ship because the occurrence area tends to be wide. Therefore, there is a need for remote sensing was by using satellites (Oh and Yoon, 2012).

The early satellite image-based red tide detection technique was concentrated mainly the retrieving of Chlorophyll-*a* concentrations (Stumpf *et al.*, 2003; Tomlinson *et al.*, 2004). However, the Chlorophyll-*a* concentration calculated from satellite images has

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a disadvantage that the accuracy is low in areas with high concentrations of dissolved organic matter and suspended matter (Bak *et al.*, 2016).

In order to solve these weakness, recent studies used optical properties of sea water(Kim *et al.*, 2007; Kim *et al.*, 2009; Son *et al.*, 2011; Son *et al*., 2012). The method that using the optical properties of sea water is advantageous that it is less distorted by the atmosphere. However, this method has a disadvantage that the calculation process is complicated.

Therefore, this study proposes an algorithm to detect red tides based on the optical properties of seawater and to simplify the calculation process.

2 Data and Methodology

2.1 Data

In this study, red tide pixel separation was attempted to use GOCI Level1B data. Level 1B data of the GOCI that has been subjected to geometric correction and radiation correction were atmospheric corrected by using GDPS (GOCI Data Processing System). Among the Level2A, B, C and P data obtained from the atmospheric correction, Level 2A(Water-leaving radiance) data and Level 2B(Absorption coefficient) data were used.

Comparisons were carried out with the red tide alert data from the National Institute of Fisheries Science. The red tide alert data includes the location of the red tide and the biological density(Cell Abundance; cells/L) information obtained at the time of red tide occurrence.

2.1 Methodology

The proposed algorithm detected red tide by eliminating clear water pixels and turbid water pixels through two-step filtering(Figure 1). In the first step, clear water pixels were removed by using the difference in the slope of the Water-leaving radiance spectrum of *C. polykrikoides* and clear water(Kim *et al.*, 2007; Bak *et al.*, 2016). In the second step, it was compared to the spectral similarity between low-concentration turbid water, high-concentration turbid water, and high-concentration Chlorophyll-a pixel spectral data for pixels that finished first stage. At this time, the most similar pixel to the spectral data of the high concentration Chlorophyll-a pixel is selected. In order to evaluate the similarity of spectrum, DTW(Dynamic Time Warping) technique was used. DTW is a method used to measure the similarity between consecutive sequence data and is mainly used for speech recognition(Park *et al.*, 2011). The reference data used to evaluate the similarity of the spectra were generated by averaging 40 spectra extracted from the GOCI images taken on a cloudless clear day. The high concentration turbid water spectrum was extracted from the western area of the South Sea of Korea and the southern area of the Yellow Sea of Korea. The low concentration turbid water spectrum was extracted from the central area of the South Sea of Korea. The high concentration of Chlorophyll-a spectrum was extracted from higher then $8\mathrm{mg}/m^3$ of

Chlorophyll-a from among the images that was taken on the day of red tide occurred. At this time, the YOC(OC algorithm for Yellow Sea of Korea) algorithm was used to calculate chlorophyll-a concentration in the turbid waters.

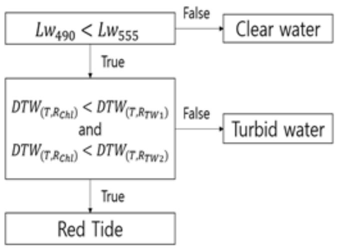

Fig. 1. Flow Chart of research(R_{Chl} : High Chlorophyll-a, R_{TW1} : Low Turbid water, R_{TW2} : High Turbid water).

3 Results and Discussion

Figure 2 shows the results of the detection of red tide from the GOCI image and the rapid news on red tide alert from National Institute of Fisheries Science on August 14, 2013, when the red tide occurred in the southern coast of Korea. It detected the red tide of the eastern sea of Namhae which is comparatively clear of the sea. In addition, the red tide of Yeosu around the high concentration of dissolved organic matters and suspended sediments was also detected. Most of the red tide in the sea area was detected. However, additional detected pixels that were not in red tide alert were found.

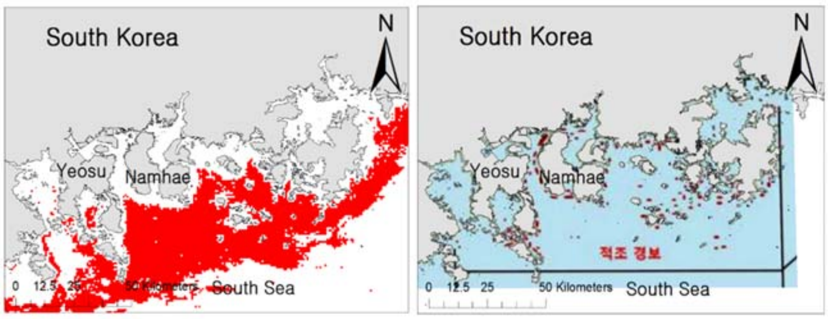

Fig. 2. Detection of red tide from GOCI image(Left) and the rapid news on red tide alert from National Institute of Fisheries Science(Right) on Aug. 14, 2013.

In the case of red tide alert, only the red tide confirmed around the coastal farm is displayed. Compared with the RI (Red tide Index; Ahn and Shanmugam, 2006), which is the official red tide output of GOCI, the actual red tide area is considered to be wider(Figure 3).

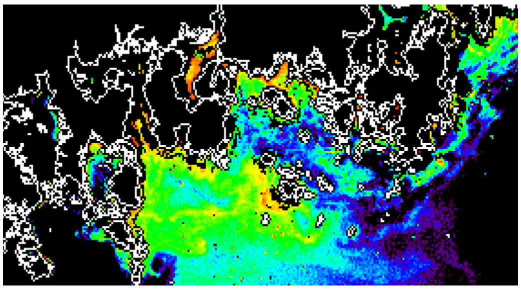

Fig. 3. Result of RI(Red tide Index for GOCI) on Aug. 14, 2013.

4 Conclusion

In this study, we propose a red tide detection technique by comparing spectrum similarity. The detection process was simplified to two stages. In addition, red tides could be detected even in areas with high concentrations of suspended solids and dissolved organic matter. Comparing the detection results with the red tide breaking data of the National Institute of Fisheries Science, it showed an overestimation tendency. This is because the rapid news on red tide alert is designed for the area around the coast where the coast is located. If we use the spectrum obtained from the field as a reference, we will show higher detection accuracy than the present. In addition, the red pixels detected at the origin should be compared with field data.

If these limitations are supplemented in the future, it is expected that it will contribute to reduction of red tide monitoring cost.

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